New fit to inclusive electron scattering for A>1 (and free neutron)

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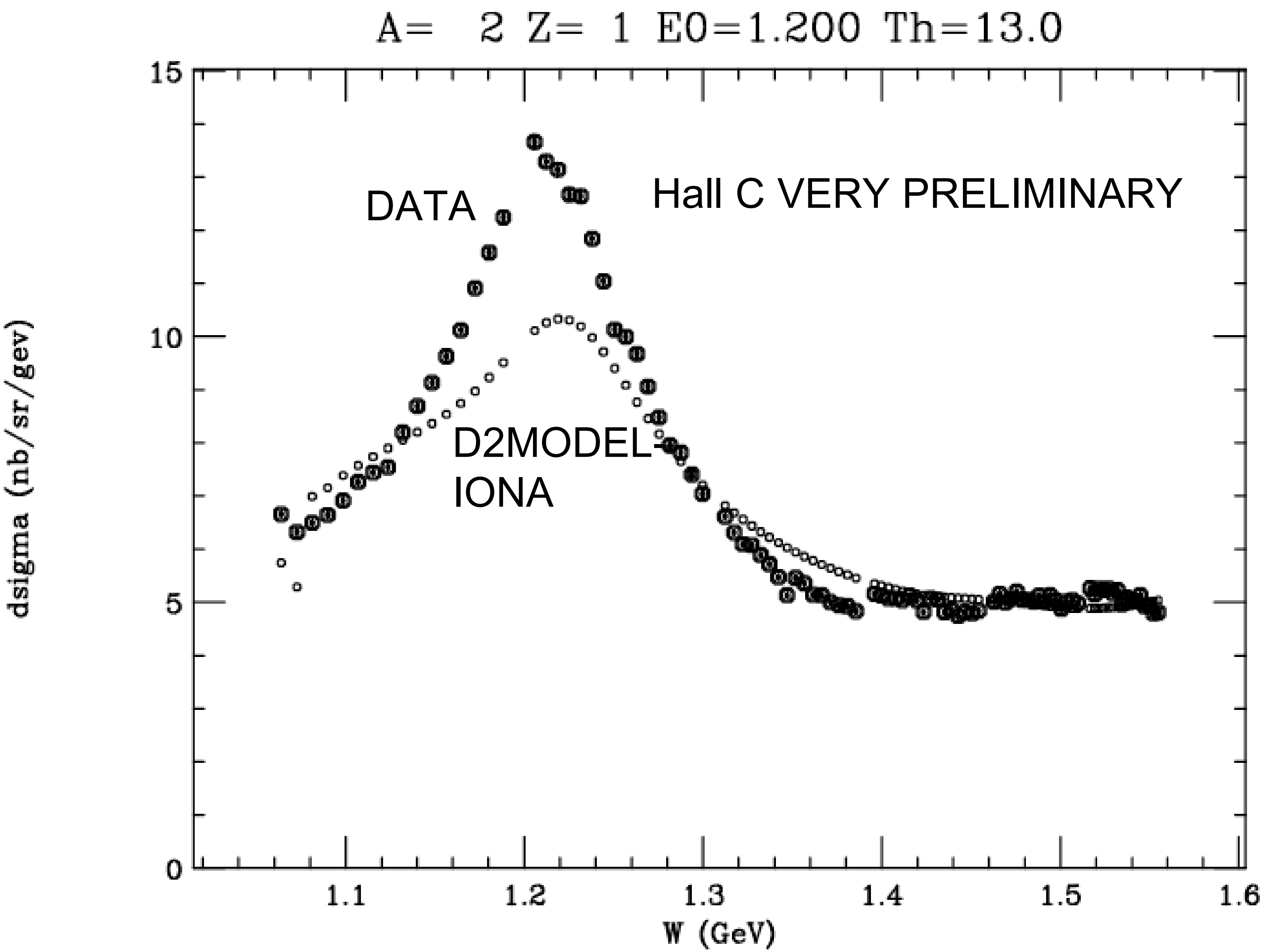
January 22 2006

- **Needed for radiative correction calculations and bin-centering.**
- **Needed to get “dilution factor” in experiments using NH_3 or ND_3 targets to measure g_1 and g_2.**
- **Helpful in sum rule evaluations.**
- **Needed to predict PV asymmetry in ep inelastic scattering.**

Inelastic scattering on deuteron

- Previous fits did not specifically include Fermi smearing effect : fixed widths of resonances were used rather than ones that increase with q.

- This can be seen on next slide for the lowest Q^2 (about 0.1 GeV^2) preliminary radiated cross section data from the recent Jlab January 2005 experiment.


A= 2 Z= 1 E0=1.200 Th=13.0
DATA
Hall C VERY PRELIMINARY
D2MODEL-
IONA
dsigma (nb/sr/gev)
W (GeV)
0
5
10
15
1.1
1.2
1.3
1.4
1.5
1.6

What is Fermi-smearing

- Nucleons move in nuclei with characteristic "Fermi" momentum controlled by nuclear density.
- Typical values are 0.05 GeV for D, 0.15 GeV for 3He, 0.2 GeV for 3<A<12, and 0.25 GeV for A>12.
- In inclusive electron scattering, "smears" out invariant mass W by:

$$W^2 = M^2 + 2M\nu - Q^2 + 2\vec{q}\cdot\vec{p_f}$$

More on Fermi smearing

- So ture W and measured W differ by magnitude of momentum transfer vector times struck nucleon momentum
- For deuteron, I use Paris wave function to estimate probability of finding a nucleon with a given value of p*cos(θ), where θ is angle between q and p.
- For A>2, use y-scaling functions from Sick, Donnelly et al. super-scaling model (generalization of their quasi-elastic model).

Basic structure of the fit

- ➢First, coded quasi-elastic superscaling model of Sick and Donnelly (code is called F1F2QE06.f). For A=2, use exact Paris wave function instead of their y-scaling function. Checked that agrees with PWIA version of J.M. Laget's code.

- ➢Next, collected together available cross sections for inelastic electron scattering from deuterium. Also collected photo-production data (Q^2=-0).

Basic structure of the fit

- Next, subtract off quasi-elastic contributions, after checking good agreement with data near W=M.
- Next, extract F_1 from cross section using Eric Christy model of $R=\sigma_L/\sigma_T$, assuming R is same for proton and deuteron.
- Underlying fit parameters describe F_1 from the sum of a free proton plus a free neutron. Functional from similar to Eric's proton fit (relativistic Breit-Wigner resonances plus polynomial non-resonant background).

Basic structure of the fit

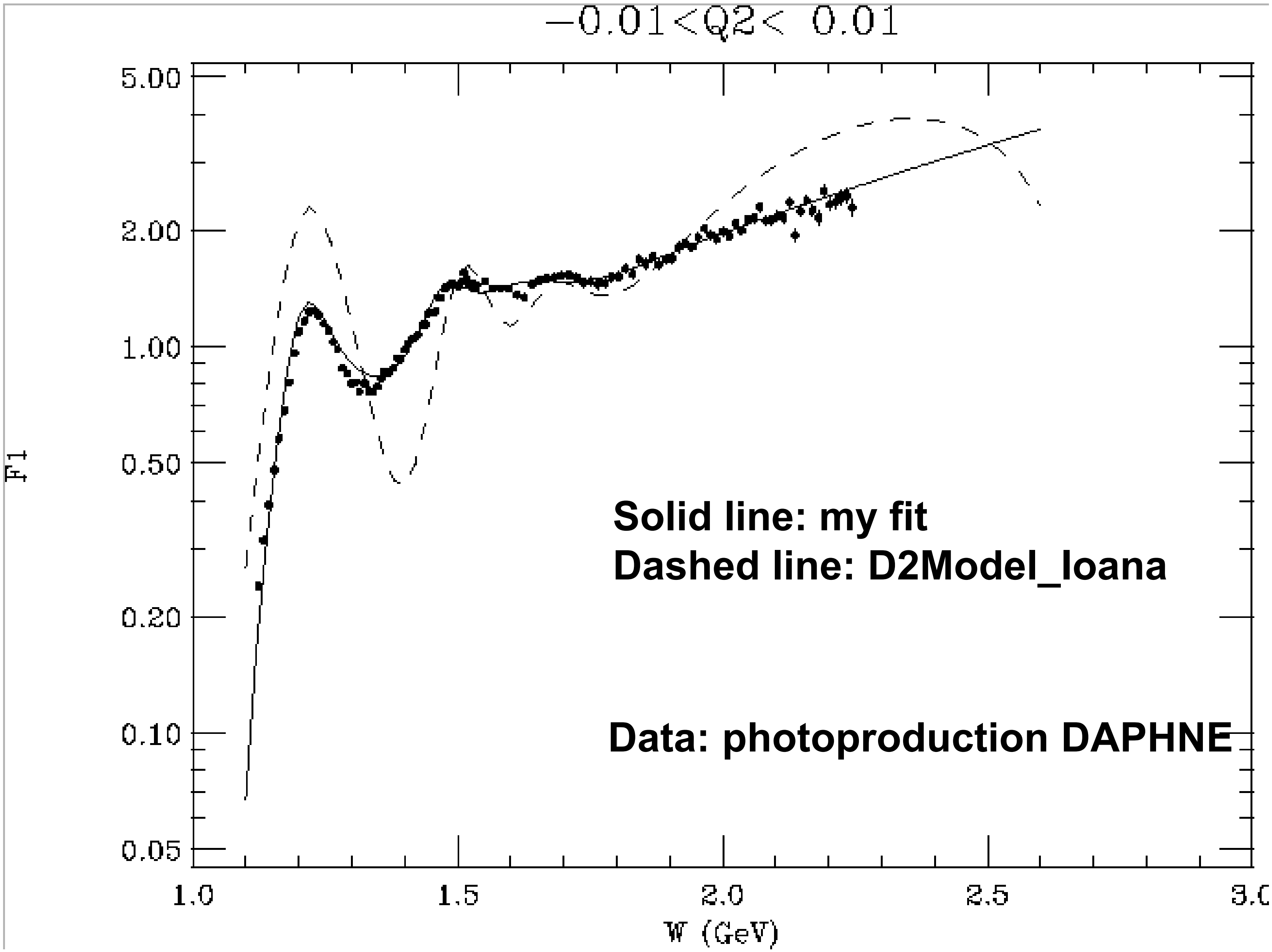
- Underlying fit is Fermi-smeared using 20 bins of equal probability in dW, for comparison with actual data. Crucial step is very efficient coding of Fermi smearing.

- Additional parameters are used to describe effects beyond Fermi-smearing such as Final State Interactions (FSI) and Meson Exchange Currents (MEC). This fills in the “dip” between quasi-elastic and Delta(1232). For A>2, this part assumed to scale with average nuclear density.

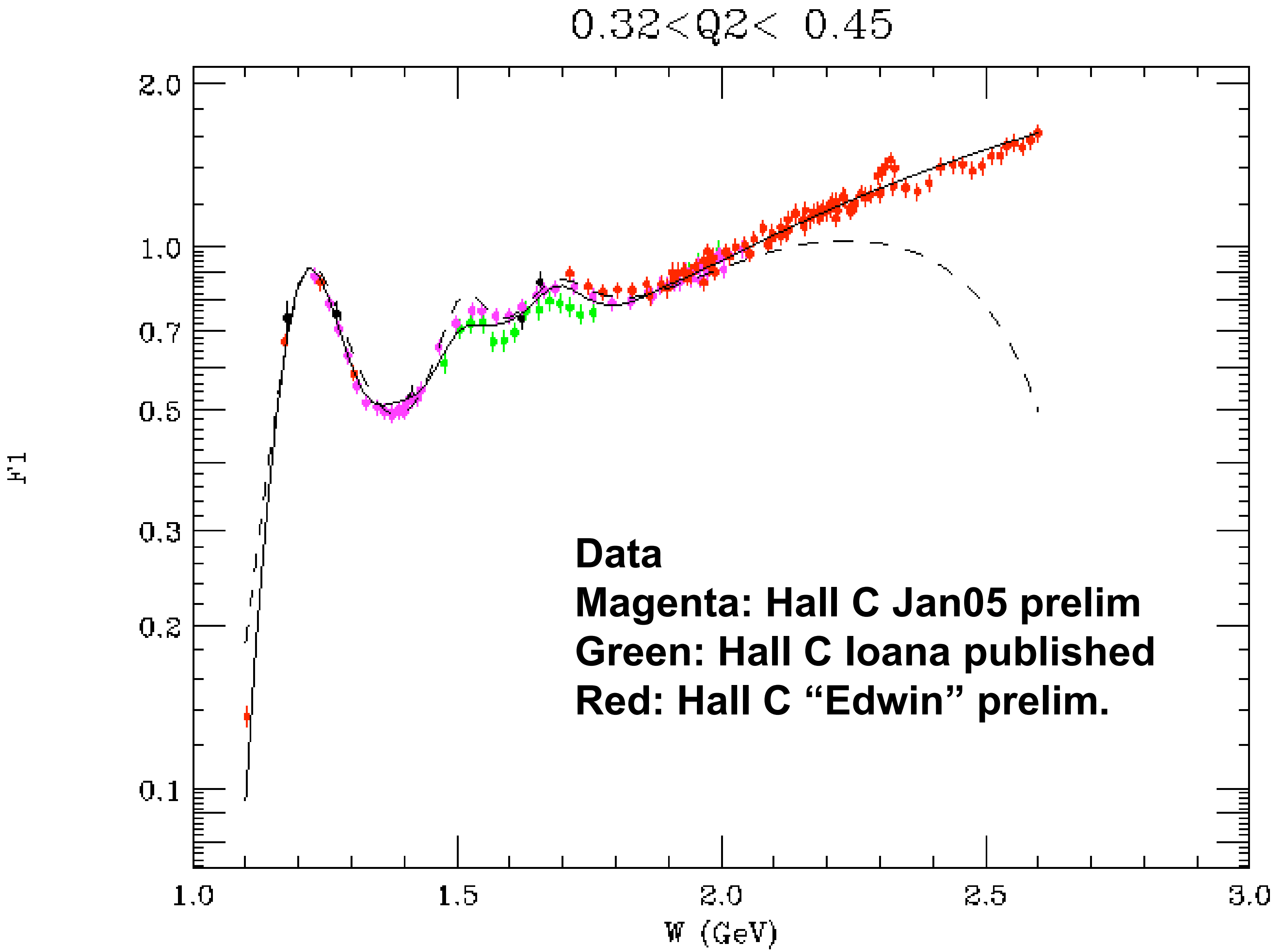
Basic structure of the fit

- Also speeded up code by pre-calculating resonance parameters (for example branching ratios for single pion, double pion, or eta) as a function of W and storing for later use.
- Used 1/10 of data to get starting parameters, then full data to refine results.

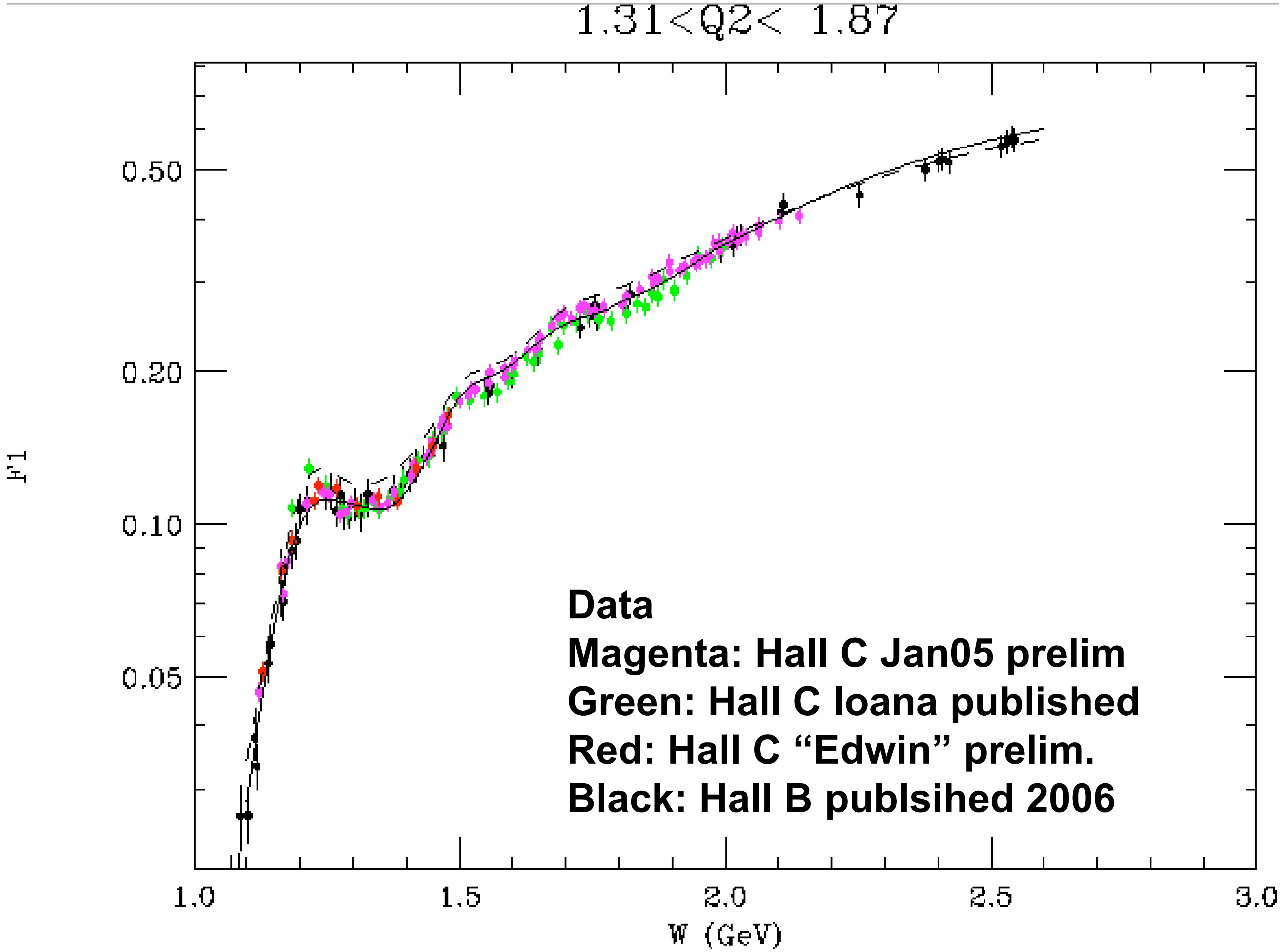
Fit compared to deuteron data



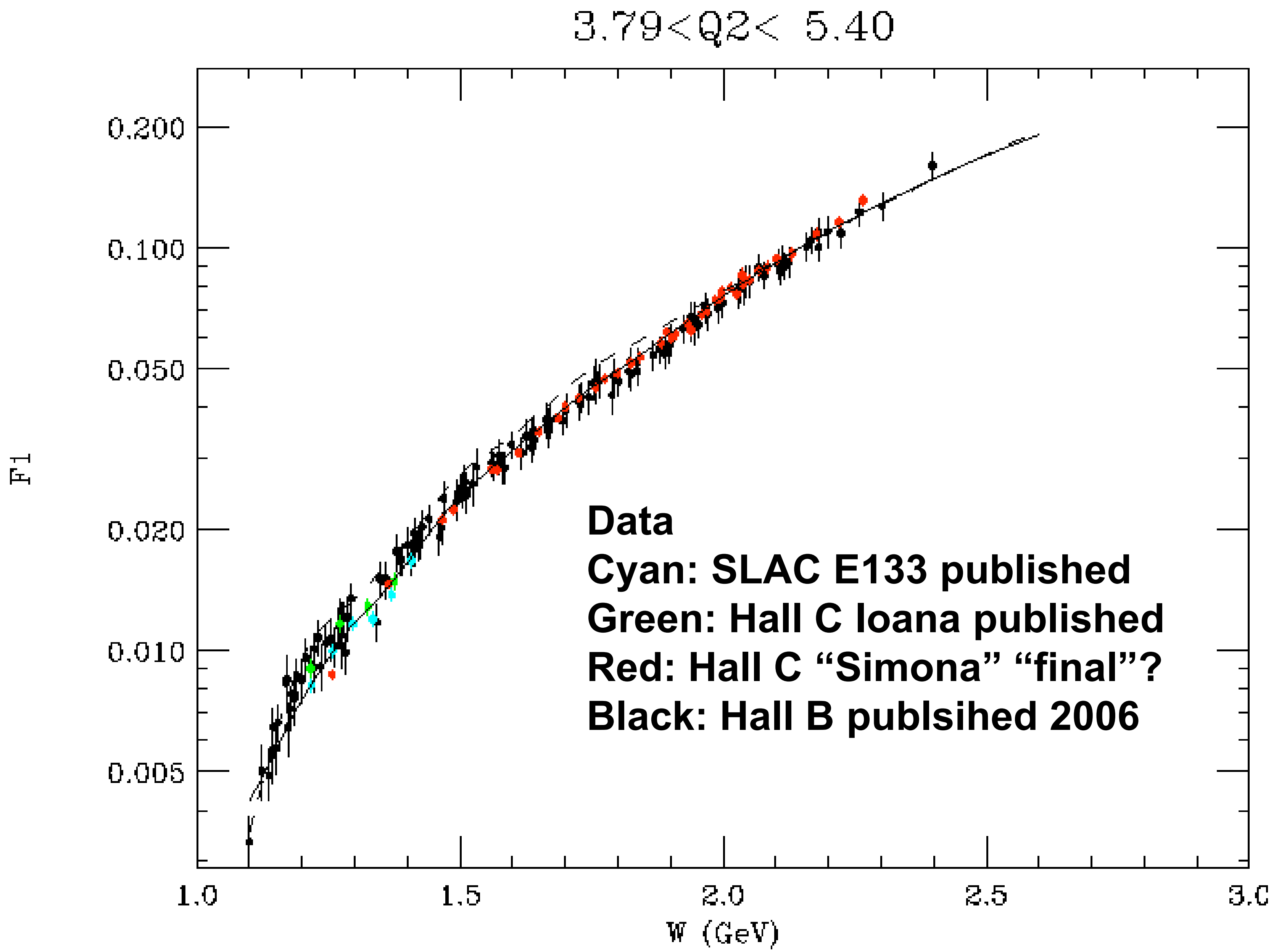
Fit compared to deuteron data



Fit compared to deuteron data



Fit compared to deuteron data

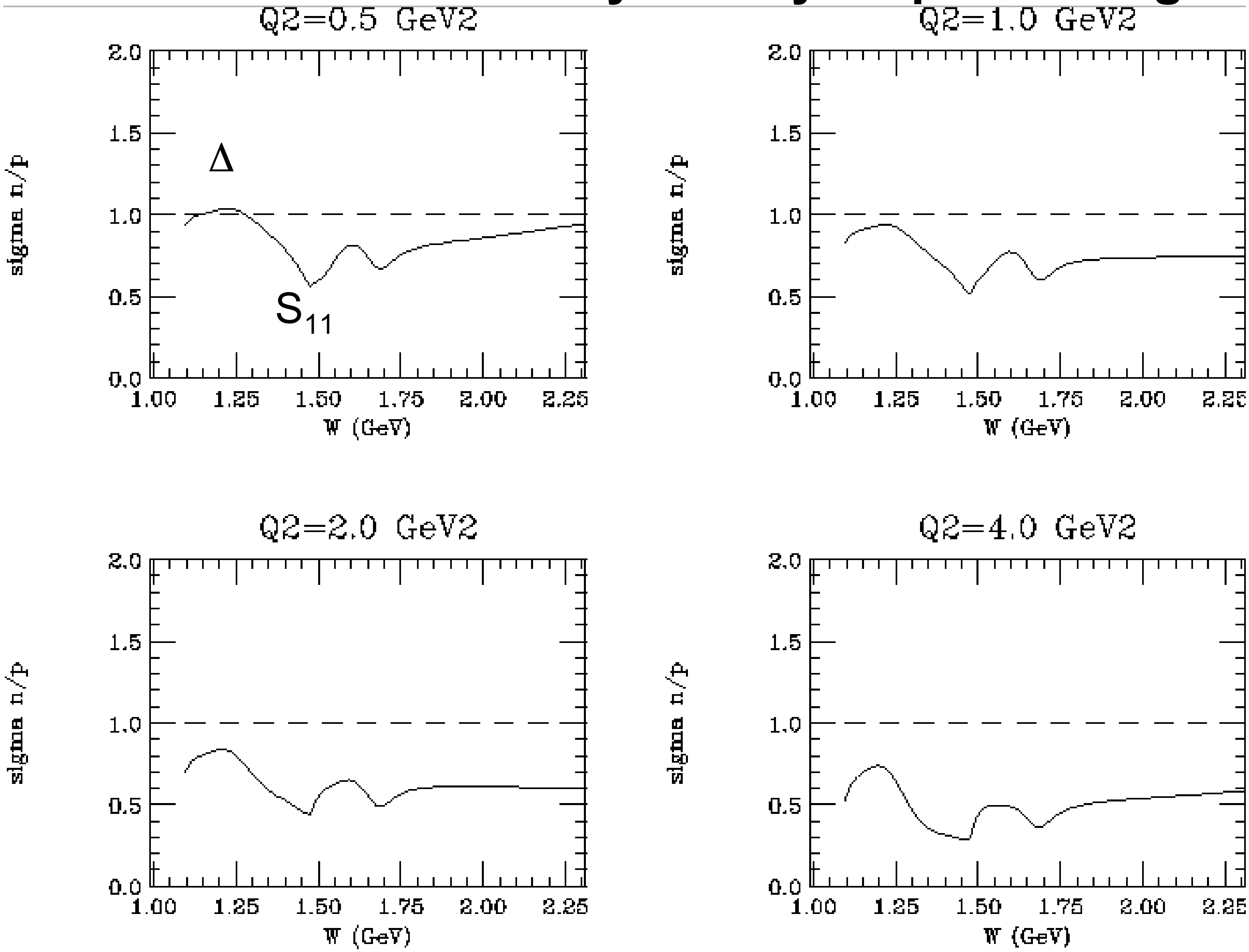


Comparisons to Data Sets

Experiment	ptp syst. added	in fit?	χ^2/d.f.
Photoproduction	none	yes	31
Hall B 2005	publsihed	yes	1.4
Hall C Ioana	2%	yes	2.7
Hall C Simona	2%	yes	2.2
SLAC E133	2%	yes	3.0
Hall C Jan05	3%	yes	3.6
Hall C Edwin	3%	no	1.9
Hall C XEMCP A=2	3%	no	7.9
Hall C XEMCP A=3	3%	no	12.2
Hall C XEMCP A=12	3%	no	6.5

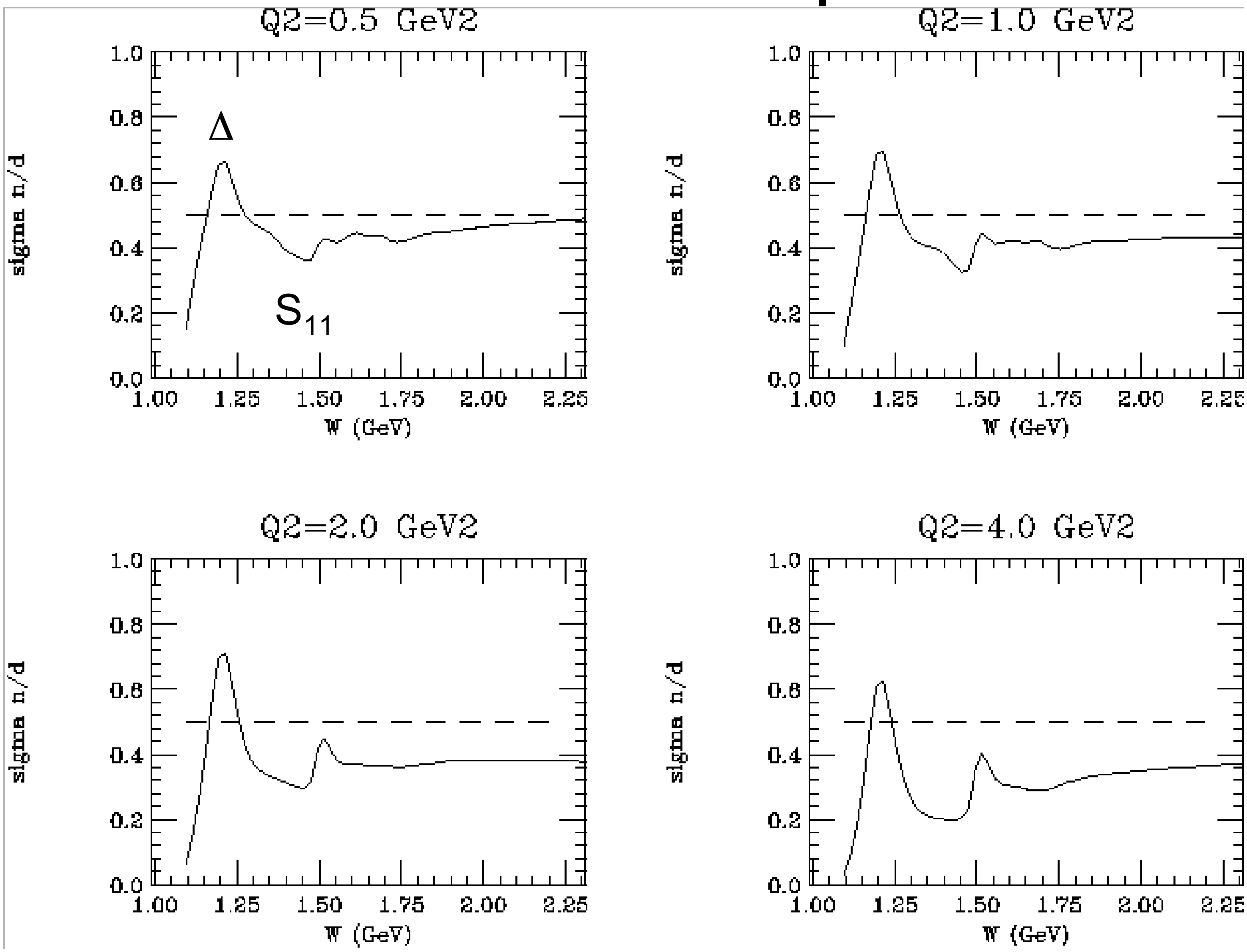
Fit results for F_1 ratio free n/p: isospin dependnce

Enters into PV asymmetry on proton target



Fit results for F_1 ratio free n/d: isospin dependence

Predictions for BONUS experiment in CLAS



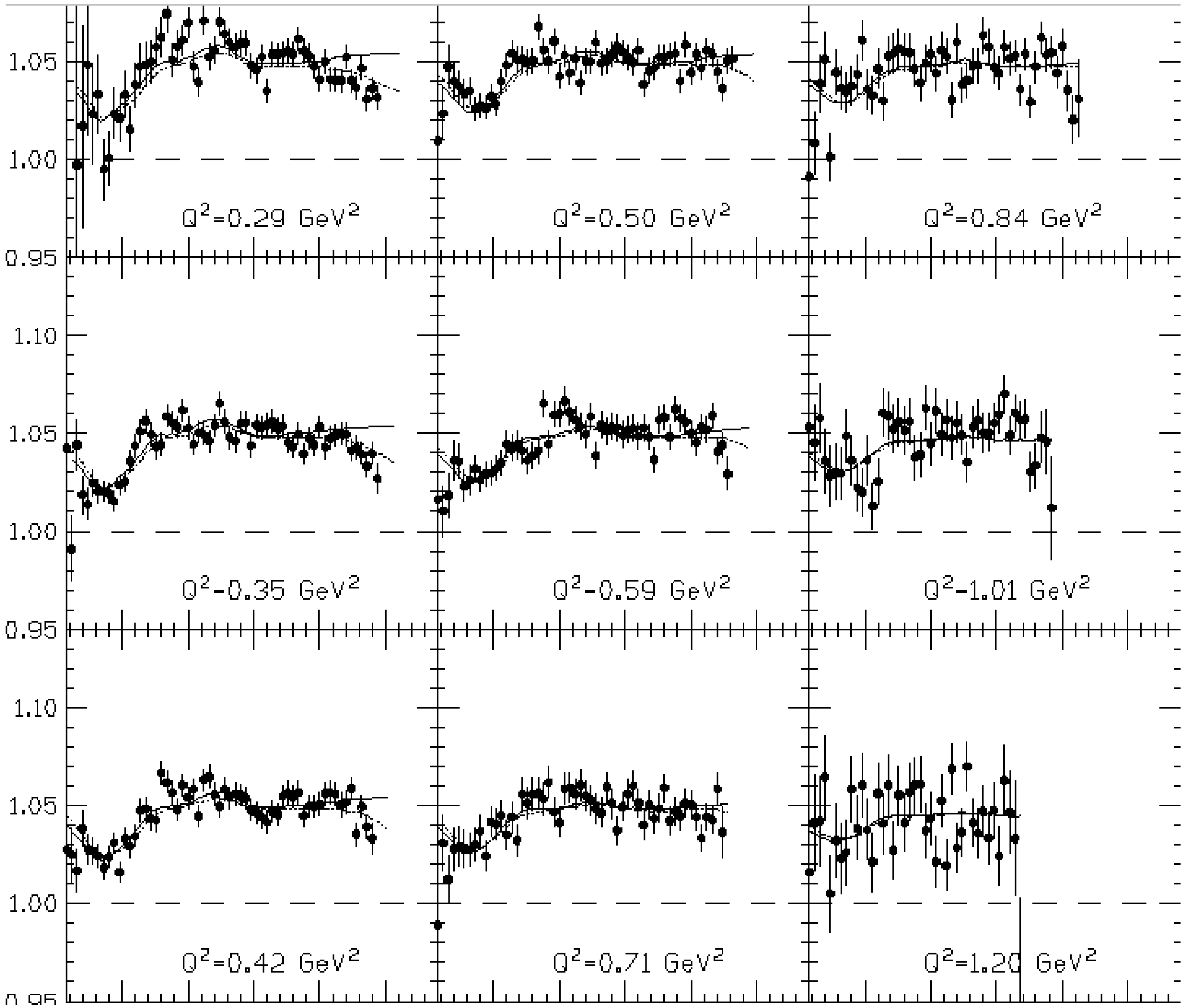
To do for deuteron and free neutron

- Include data at higher W (W>3), or use NMC fit.
- Better consistency of proton and neutron fit forms. Improve underlying physics (for example, Roper is thought to have a diffractive minimum at moderate Q^2).
- Find photoproduction data W>2.5 GeV.
- Finalize Hall C results from “Edwin”, “Jan05”, “NucR”, “Simona”. Reanalyze “Ioana” (bin centering, rad. corr.)

Inelastic scattering on nuclei

- Presently, apply simple y-scaling-based Fermi smearing model to free neutron and proton fits, plus a Steve Rock fit to “EMC” ratio for $x<0.8$ to take into account binding and shadowing.
- This prescription predicts ratio of ^{15}N to C essentially independent of W in the resonance region, except at q.e. peak.
- This seems to be born out by preliminary ratios measured in CLAS.

Preliminary ratios 15N/C (per gm) from CLAS Eg1b



W (GeV)

CONCLUSIONS

- **New fit to quasi-elastic plus inelastic for A=2 seems pretty good, at least to do radiative corrections. Range of validity larger than previous fits ($0<Q^2<10$ GeV^2, W<3 GeV).**

- **Data from Jan05 and F2LowQ2 (Ewdin) crucial to constrain low Q2 behavior.**

- **Need to study behavior A>2, espeically for $Q^2<1$ GeV^2 (higher Q^2 seems o.k. using traditional "EMC" correction).**